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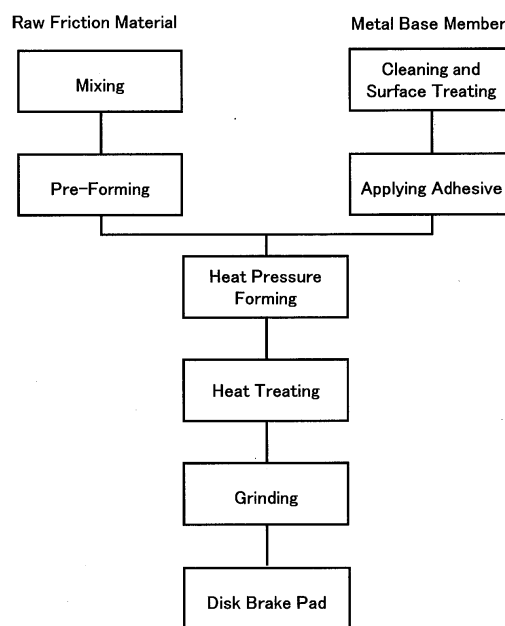
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(54) **FRICTION MATERIAL**

(57) The present invention relates to the friction material for the use of disc brake pads and brake shoes for automotive brake devices, and an object of the present invention is to provide the friction material with sufficiently stable braking force and sufficient mechanical strength. In the friction material without a metal or a metal alloy, the friction material includes the plate-like titanate with average particle diameter of 10 to 50 μm and the hydrous magnesium silicate. An amount of the plate-like titanate and the hydrous magnesium silicate is 20 to 30 volume percent relative to the total amount of the friction material, and the volume ratio of the plate-like titanate and the hydrous magnesium silicate is 12:1 to 5:1. Also, the average particle diameter of the plate-like titanate is 20 to 40 μm , and the plate-like titanate is preferably potassium hexatitanate.

FIG. 1



Description**[TECHNICAL FIELD]**

5 **[0001]** The present invention relates to a friction material to be used for such as automotive disc brake pads and brake shoes.

[BACKGROUND ART]

10 **[0002]** Conventionally, a disc brake and a drum brake are utilized as the automotive brake device, and disc brake pads and brake shoes made by fixing the friction material on a base member made of metal such as steel are utilized as a friction member of the brake device.

15 **[0003]** A friction material can be classified into three types, (1) a semi-metallic friction material including a large amount of steel fiber as a fiber base material, (2) a raw steel friction material including steel fibers in a part of the fiber base material, and (3) a Non-Asbestos-Organic (NAO) friction material including nonferrous metal fibers as a fiber base material. A friction material that causes less brake noise is demand. The friction material that uses NAO friction material has been widely used, where the friction material does not include a ferrous metal fiber such as a steel fiber and a stainless steel fiber but includes a fiber base material such as a nonferrous metal fiber, an organic fiber and an inorganic fiber, a binder such as thermosetting resin, and a friction modifier such as an organic filler, an inorganic filler, an inorganic abrasive, a lubricant and a metal particle.

20 **[0004]** A nonferrous metal fiber and/or particle such as aluminum, copper, zinc, and tin and a nonferrous metal alloy fiber and/or particle such as bronze and brass have been used as the NAO friction material.

25 **[0005]** The Japanese provisional patent publication no. 2001-107026 (Patent Document 1) discloses the friction material formed by heat press forming a friction material compositions including 1-10 weight percent of zinc fiber with the length of 1-10mm relative to the total amount of the friction material compositions and the above-explained friction material compositions. The Japanese provisional patent publication no. 2002-97455 (Patent Document 2) discloses the friction material compositions including 1-20 weight percent of phosphor bronze fiber with the length of 0.5-10mm relative to the total amount of the friction material compositions and the friction material formed by heat press forming the friction material compositions. The Japanese provisional patent publication no. 2010-285558 (Patent Document 3) discloses the friction material that at least includes a fiber base material, a friction modifier, and a heavy metal material such as a copper and that formulates at least one type of hydroxyapatite and 1-10 volume percent of zeolite.

30 **[0006]** The friction material that includes these nonferrous metal fiber and/or particle and nonferrous metal alloy fiber and/or particle, when making a frictional engagement with the mating member such as a disc rotor and a brake drum, forms a thin transferred film of nonferrous metal and nonferrous metal alloy on the frictional surface of the mating member. Then, the transferred film and the nonferrous metal and nonferrous metal alloy components existing on the frictional surface of the friction material create an adhesive friction, thereby enabling and creating a braking force.

35 **[0007]** However, the adhesive friction of the nonferrous metal and nonferrous metal alloy heavily depends on temperature. Therefore, the braking force may be unstable depending upon the temperature range of the friction material. Also, metal catch, that friction dust of the mating member adheres to the friction material, tends to generate, thereby ultimately leading to a scoring problem.

40 **[0008]** Furthermore, in recent years, due to environmental consciousness, a friction material that does not contain heavy metal material such as copper and lead is becoming more desirable.

45 **[0009]** On the other hand, regardless of ferrous and nonferrous, the metal and metal alloy fibers have been used as the fiber base material in order to secure a mechanical strength of the friction material, and the problem is that, without the metal and/or metal alloy fibers, sufficient mechanical strength cannot be obtained.

[PATENT LITERATURE]**[0010]**

50 [Patent Document 1] Japanese Provisional Patent Publication No. 2001-107026
 [Patent Document 2] Japanese Provisional Patent Publication No. 2002-97455
 [Patent Document 3] Japanese Provisional Patent Publication No. 2010-285558

[SUMMARY]

55 **[0011]** The present invention has been made in view of the above-circumstances. The present invention relates to the friction material used for the brake pad and the brake shoe of the automotive brake device, and an object of the present

invention is to provide the friction material with sufficiently stable braking force and sufficient mechanical strength.

[0012] For the purpose of securing sufficient mechanical strength of the friction material without metal and/or metal alloy fibers, a relatively large amount of plate-like titanate was added as the inorganic filler having stiffening effect. However, when the large amount of plate-like titanate was added, the plate-like titanate transferred film formed on the frictional surface of the mating member excessively becomes thick while making a frictional engagement between the friction material and the mating member, and as a result, the friction coefficient decreases and no sufficient braking force can be obtained.

[0013] Normally, in order to adjust an appropriate thickness of the transferred film, the amount of the abrasive materials that grind the transferred film is increased or more stiff abrasive materials are added; however, such a technique tends to increase a chance of generating the braking noise.

[0014] The inventors of the present invention considered that a more effective means to adjust the appropriate thickness of the plate-like titanate transferred film is to decrease the strength of the plate-like titanate transferred film rather than arranging the amount and types of the abrasive materials and focused on the decrease of the strength. Then, the inventors combined the plate-like titanate and hydrous magnesium silicate to obtain the combination transferred film of the plate-like titanate and hydrous magnesium silicate that has less strength than the plate-like titanate transferred film and therefore reached the present invention that can control the appropriate thickness of the transferred film without adding more stiff abrasive materials.

[0015] The present invention is a friction material that does not include a ferrous metal, a nonferrous metal, and a nonferrous metal alloy, i.e., not including a metal or a metal alloy but includes the plate-like titanate and hydrous magnesium silicate in specific average particle diameter and in a specific percentage content and is based on the following technologies.

[0016] (1) A friction material that does not include a metal or a metal alloy, in which the friction material includes the plate-like titanate in the average particle diameter of 10 to 50 μ m and hydrous magnesium silicate, where an amount of the plate-like titanate and the hydrous magnesium silicate is 20 to 30 volume percent relative to the total amount of the friction material, and the volume ratio of the plate-like titanate and the hydrous magnesium silicate is 12:1 to 5:1.

[0017] (2) The friction material of the above (1), in which the average particle diameter of the plate-like titanate is 20 to 40 μ m.

[0018] (3) The friction material of the above (1) or (2), in which the plate-like titanate is a potassium hexatitanate.

[0019] It is an object of the present invention to provide the friction material that has sufficient and stable braking force and sufficient mechanical strength.

[BRIEF DESCRIPTION OF DRAWINGS]

[0020]

FIG. 1 is a view showing one example of the manufacturing process of the disc brake pad utilizing the friction material of the present invention;

FIG. 2 is a perspective view showing one example of the disc brake pad utilizing the friction material of the present invention;

FIG. 3 is a view showing one example of the manufacturing process of the brake shoe utilizing the friction material of the present invention; and

FIG. 4 is a perspective view showing one example of the brake shoe utilizing the friction material of the present invention.

[DESCRIPTION OF EMBODIMENTS]

[0021] In the present invention, the friction material is arranged so that an amount of the plate-like titanate with average particle diameter of 10 to 50 μ m and the hydrous magnesium silicate is designed to be 20 to 30 volume percent relative to the total amount of the friction material and the volume ratio of the plate-like titanate and the hydrous magnesium silicate is designed to be 12:1 to 5:1.

[0022] If the prescription of the plate-like titanate and the hydrous magnesium silicate deviates from the above-ranges, (1) the friction material may not obtain sufficient mechanical strength, (2) the wear resistance may be adversely affected, (3) in the case that a strength of the transferred film formed on the frictional surface of the mating member become too large, an excessive thickness of the transferred film is generated, and then the frictional coefficient decreases, in the result, the friction material may not obtain sufficient braking force, and (4) in the case that a strength of the transferred film becomes too little, the transferred film is not generated, and then frictional coefficient decreases, in the result, the friction material may not obtain sufficient braking force.

[0023] When the average particle diameter of the above-described plate-like titanate is 20 to 40 μ m, the balance

between the braking force and the mechanical strength becomes preferable and it is desirable. Also, the plate-like titanate may be such as potassium hexatitanate, potassium octatitanate, lithium potassium titanate, and magnesium potassium titanate, but using potassium hexatitanate with high heat resistance improves the wear resistance and is preferable.

Here, the average particle diameter of the present invention is 50 percent. The particle diameter is measured by a Laser Diffraction-type Particle Size Distribution Measuring Method.

[0024] In addition to the above-described plate-like titanate and hydrous magnesium silicate, the friction material of the present invention includes materials that are normally used for the friction material, for example, fiber base materials such as organic fibers and inorganic fibers, binders such as thermosetting resin, and friction modifiers such as organic fillers, inorganic fillers, and lubricants.

[0025] The fiber base material may be organic fibers such as aramid fibers and acrylic fibers and inorganic fibers such as carbon fibers, ceramic fibers, and rock wool, and these fibers can be used alone or in combination. The content of the fiber base material, in order to secure the sufficient mechanical strength, is preferably 5 to 60 volume percent relative to the total amount of the friction material and 10 to 50 volume percent relative to the total amount of the friction material is more preferable.

[0026] The binder may be the thermosetting resin such as a phenolic resin and epoxy resin, a resin obtained by modifying these thermosetting resins with various elastomers such as cashew oil and silicon oil, and a resin obtained by dispersing the various elastomers and fluorinated polymer on the thermosetting resin. These resins may be used alone or in combination.

[0027] The content of the binder, in order to secure the sufficient mechanical strength and wear resistance, is preferably 10 to 30 volume percent relative to the total amount of the friction material and more preferably 12 to 25 volume percent relative to the total amount of the friction material.

[0028] The friction modifier may be organic fillers such as cashew dusts, rubber dusts (pulverized rubber powder of tire tread rubber), and various unvulcanized rubber particles and various vulcanized rubber particles, inorganic fillers such as barium sulfate, calcium carbonate, calcium hydroxide, vermiculite, and mica, and lubricants such as molybdenum disulfide, tin sulfide, zinc sulfide, and iron sulfide. These friction modifiers may be used alone or in combination.

[0029] The content of the friction modifier should be adjusted according to the desirable frictional characteristics but is preferably 40 to 70 volume percent relative to the total amount of the friction material and is more preferably 50 to 70 volume percent relative to the total amount of the friction material.

[0030] The friction material of the present invention is manufactured through a mixing step of stirring the mixture of the predetermined amount of the above-described plate-like titanate, the hydrous magnesium silicate, the fiber base material, the binder, and the friction modifier by a mixer, a heat press forming step of filling the obtained raw friction material mixture into a heat forming die to heat-press-form the same, a heat treatment step of heating the obtained heat product to complete the binder curing, and a grinding step to form the friction surface. As necessary, prior to the heat press forming step, a granulation step of granulating the raw friction material mixture and a pre-forming step of forming a preformed product by filling the raw friction material mixture or granulated raw friction material mixture into a pre-forming die may be conducted, and after the heat press forming step, a coating step, a baking after coating step, and/or a scorching step are conducted.

[0031] When manufacturing the disc brake pad, in the heat press forming step, the forming process is performed while superposing the metal back plate such as steel back plate, which is pre-washed, surface treated, and coated with adhesive, with the above-described raw friction material mixture or the granulated product and the preformed product.

[Embodiments]

[0032] Preferred embodiments and comparative examples of the present invention will be explained in concrete but the present invention is not limited to the following embodiments.

[Manufacturing Method of Friction Material According to Embodiments 1-9 and Comparative Examples 1-7]

[0033] The frictional material compositions as shown in TABLES 1 and 2 are stirred for 5 minutes using Loedige mixer and the mixture is pressed in the preforming die under 10MPa for 1 minute. This preformed product is superposed on the steel back plate that is prewashed, surface treated and coated with adhesive, and the preformed product with the back plate is heated at the forming temperature of 150 degrees centigrade and pressurized under the forming pressure of 40MPa in the heat forming die for 10 minutes. Then, the resultant product is heat treated (post-curing) at 200 degrees centigrade for 5 hours and is grinded to make the automotive disc brake pad (see Embodiments 1-9 and Comparative Examples 1-7). Regarding the mechanical strength, the wear resistance, braking force, and stability of braking force are evaluated. The results of the evaluation can be seen in TABLES 1 and 2.

[TABLE 1]

		Embodiments								
		1	2	3	4	5	6	7	8	9
5	Fiber Base	Para-aramid Pulp	13	13	13	13	13	13	13	13
		Copper Fiber	0	0	0	0	0	0	0	0
10	Binder	Straight Phenolic Resin	10	10	10	10	10	10	10	10
		Acrylic Rubber Modified Phenolic Resin	10	10	10	10	10	10	10	10
15		Potassium Hexatitanate (average particle diameter of 5 μ m)	0	0	0	0	0	0	0	0
		Potassium Hexatitanate (average particle diameter of 10 μ m)	24	0	0	0	0	0	0	0
20		Potassium Hexatitanate (average particle diameter of 20 μ m)	0	24	24	24	0	0	18	27
		Potassium Hexatitanate (average particle diameter of 40 μ m)	0	0	0	0	24	0	0	0
25		Potassium Hexatitanate (average particle diameter of 50 μ m)	0	0	0	0	0	24	0	0
		Potassium Hexatitanate (average particle diameter of 60 μ m)	0	0	0	0	0	0	0	0
30		Potassium Hexatitanate (average particle diameter of 50 μ m)	0	0	0	0	0	0	0	0
		Potassium Hexatitanate (average particle diameter of 60 μ m)	0	0	0	0	0	0	0	0
35		Potassium Hexatitanate (average particle diameter of 50 μ m)	0	0	0	0	0	0	0	0
		Potassium Hexatitanate (average particle diameter of 60 μ m)	0	0	0	0	0	0	0	0
40		Potassium Hexatitanate (average particle diameter of 50 μ m)	0	0	0	0	0	0	0	0
		Potassium Hexatitanate (average particle diameter of 60 μ m)	0	0	0	0	0	0	0	0
45		Potassium Hexatitanate (average particle diameter of 50 μ m)	0	0	0	0	0	0	0	0
		Potassium Hexatitanate (average particle diameter of 60 μ m)	0	0	0	0	0	0	0	0
50		Potassium Hexatitanate (average particle diameter of 50 μ m)	0	0	0	0	0	0	0	0
		Potassium Hexatitanate (average particle diameter of 60 μ m)	0	0	0	0	0	0	0	0

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(continued)

		Embodiments								
		1	2	3	4	5	6	7	8	9
Inorganic Filler	Potassium Octatitanate (average particle diameter of 20μm)	0	0	0	0	0	0	24	0	0
	Hydrous magnesium silicate	3	2	3	4	3	3	3	2.5	3
	Zirconium Silicate	1	1	1	1	1	1	1	1	1
	Zirconium Oxide	3	3	3	3	3	3	3	3	3
	Mica	3	3	3	3	3	3	3	3	3
	Magnetite	3	3	3	3	3	3	3	3	3
	Cokes	5	5	5	5	5	5	5	5	5
	Zinc Sulfide	2	2	2	2	2	2	2	2	2
	Calcium Hydroxide	2	2	2	2	2	2	2	2	2
	Barium Sulfate	11	12	11	10	11	11	11	17.5	8
	Bronze Particles	0	0	0	0	0	0	0	0	0
Organic Filler	Rubber Powder of Tire Tread Rubber	3	3	3	3	3	3	3	3	3
	Cashew Dust	7	7	7	7	7	7	7	7	7
Total		100	100	100	100	100	100	100	100	100
Evaluation	Wear Resistance	Δ	○	○	○	○	Δ	Δ	Δ	Δ
	Braking Force	○	Δ	○	Δ	○	○	○	Δ	Δ
	Braking Stability	○	○	○	○	○	○	○	○	○
Note	Total of Plate-Like Titanate and Hydrous magnesium silicate	27	26	27	28	27	27	27	20.5	30
	Volume Ratio of Plate-Like Titanate and Hydrous magnesium silicate	8:1	12:1	8:1	6:1	8:1	8:1	8:1	7.2: 1	9:1

[TABLE 2]

		Comparative Examples						
		1	2	3	4	5	6	7
5	Fiber Base	Para-aramid Pulp	13	13	13	13	13	13
		Copper Fiber	0	0	0	0	0	10
10	Binder	Straight Phenolic Resin	10	10	10	10	10	10
		Acrylic Rubber Modified Phenolic Resin	10	10	10	10	10	10
15	Inorganic Filler	Potassium Hexatitanate (average particle diameter of 5 μ m)	24	0	0	0	0	0
		Potassium Hexatitanate (average particle diameter of 10 μ m)	0	0	0	0	0	0
		Potassium Hexatitanate (average particle diameter of 20 μ m)	0	0	24	24	16	28
20		Potassium Hexatitanate (average particle diameter of 40 μ m)	0	0	0	0	0	0
		Potassium Hexatitanate (average particle diameter of 50 μ m)	0	0	0	0	0	0
25		Potassium Hexatitanate (average particle diameter of 60 μ m)	0	24	0	0	0	0
		Potassium Octatitanate (average particle diameter of 20 μ m)	0	0	0	0	0	0
30		Hydrous magnesium silicate	3	3	6	1.5	2	4
		Zirconium Silicate	1	1	1	1	1	1
		Zirconium Oxide	3	3	3	3	3	3
35		Mica	3	3	3	3	3	3
		Magnetite	3	3	3	3	3	3
		Coke	5	5	5	5	5	5
		Zinc Sulfide	2	2	2	2	2	2
40		CalciumHydroxide	2	2	2	2	2	2
		Barium Sulfate	11	11	8	12.5	20	6
		Bronze Particles	0	0	0	0	0	5
45	Organic Filler	Rubber Powder of Tire Tread Rubber	3	3	3	3	3	3
		Cashew Dust	7	7	7	7	7	7
	Total		100	100	100	100	100	100
50	Evaluation	Wear Resistance	×	×	○	○	×	×
		Braking Force	Δ	Δ	×	×	○	○
		Braking Stability	○	○	○	○	○	×
55	Note	Total of Plate-Like Titanate and Hydrous magnesium silicate	27	27	30	25.5	18	-
		Volume Ratio of Plate-Like Titanate and Hydrous magnesium silicate	8:1	8:1	4:1	16:1	8:1	-

[TABLE 3]

Evaluating Items	Wear Resistance	Braking Force	Braking Stability
Evaluation Method	In accordance with JASO C427 "Wear Test Procedure on Inertia Dynamometer - Brake Friction Materials" Initial brake temp.: 100 degrees centigrade 1000 times of brake applications	In accordance with JASO C406 "Passenger Car - Braking Device - Dynamometer Test Procedure" Average Frictional Coefficient (μ) of Second effective Test	In accordance with JASO C406 "Passenger Car - Braking Device - Dynamometer Test Procedure" Difference between Average Frictional Coefficient (μ) of Second effective Test at 50km/h and at 130km/h
○	lower than 0.1 mm	0.40 or higher but lower than 0.45	Lower than 0.05
△	0.1mm or higher but lower than 0.2mm	0.36 or higher but lower than 0.40	0.05 or higher but lower than 10
×	0.2mm or higher	Lower than 0.36	0.10 or higher

[0034] According to the evaluation results of TABLES 1 and 2, the friction material of the present invention shows sufficiently stable braking force and effective mechanical strength.

[Industrial Applicability]

[0035] The friction material of the present invention is practically valuable friction material to be used in the disc brake and the drum brake for the automotive brake device and at the same time sufficiently complies with the current needs of the friction material without the heavy metal such as copper and lead.

[Reference Numbers]

[0036]

1. disc brake pad
2. back plate
3. friction material
4. brake shoe
5. brake shoe body
6. lining

Claims

1. A friction material without a metal or a metal alloy, wherein said friction material includes a plate-like titanate with average particle diameter of 10 to 50 μ m and a hydrous magnesium silicate, and wherein an amount of said plate-like titanate and said hydrous magnesium silicate is 20 to 30 volume percent relative to the total amount of the friction material, and the volume ratio of said plate-like titanate and said hydrous magnesium silicate is 12:1 to 5:1.
2. The friction material of Claim 1, wherein the average particle diameter of said plate-like titanate is 20 to 40 μ m.
3. The friction material of Claim 1 or 2, wherein the plate-like titanate is potassium hexatitanate.

FIG. 1

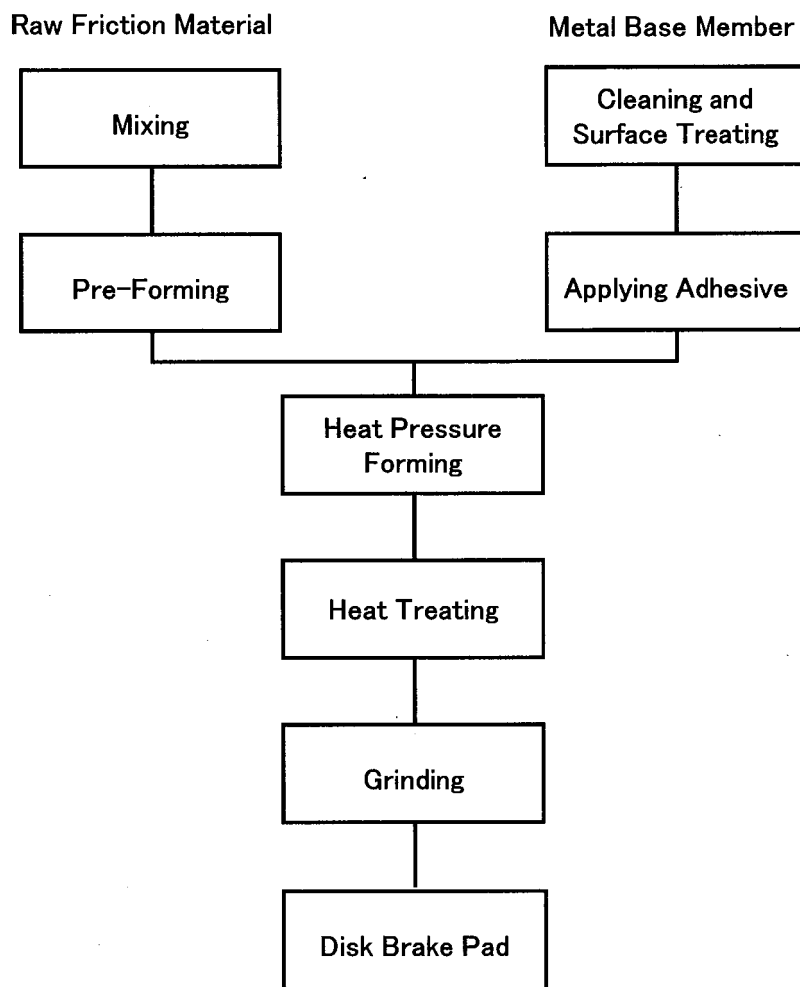


FIG. 2

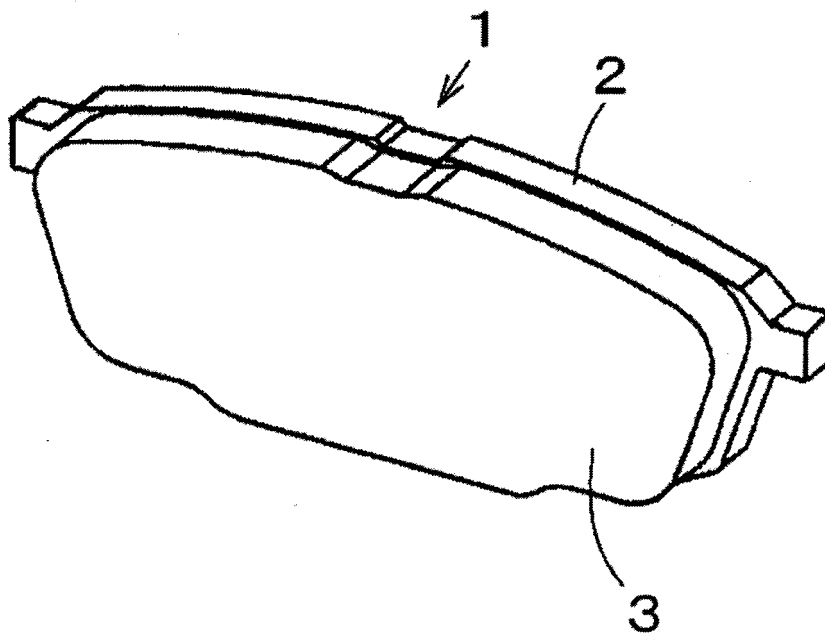


FIG. 2

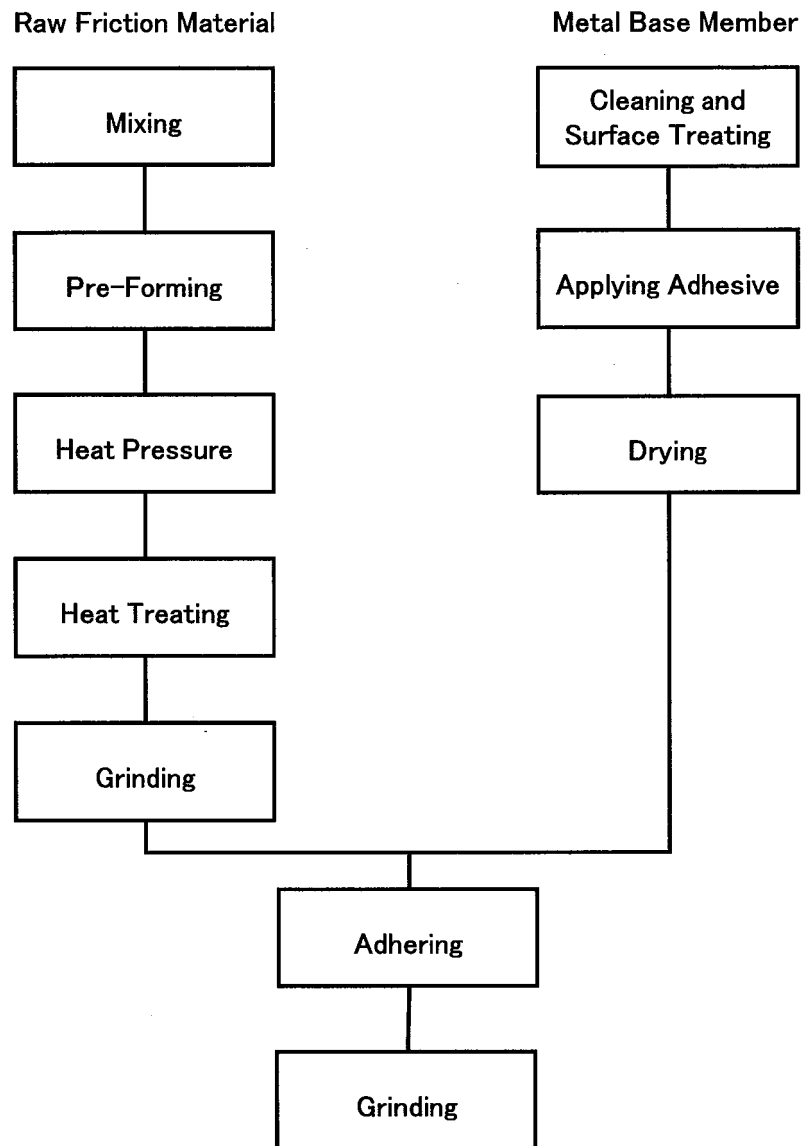
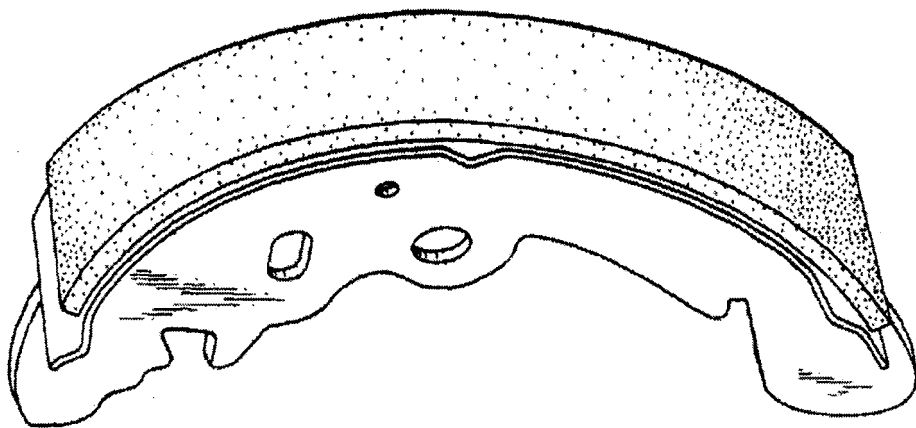


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/001760

A. CLASSIFICATION OF SUBJECT MATTER <i>C09K3/14(2006.01) i, F16D69/02(2006.01) i</i>		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) <i>C09K3/14, F16D69/02</i>		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2012 Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 1-294553 A (Kubota Corp.), 28 November 1989 (28.11.1989), claims; page 3, upper left column, line 19 to upper right column, line 19; examples (Family: none)	1-3
A	JP 2010-235730 A (Kubota Corp.), 21 October 2010 (21.10.2010), the entire specification (Family: none)	1-3
A	JP 2009-67639 A (Kubota Corp.), 02 April 2009 (02.04.2009), the entire specification & US 2010/0323876 A1 & EP 2189419 A1 & WO 2009/035166 A1 & CA 2699462 A & KR 10-2010-0040977 A & CN 101801851 A	1-3
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 04 April, 2012 (04.04.12)		Date of mailing of the international search report 17 April, 2012 (17.04.12)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/001760

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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REFERENCES CITED IN THE DESCRIPTION

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- JP 2002097455 A [0005] [0010]
- JP 2010285558 A [0005] [0010]